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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 erg/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 2, February 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
Environmental Control Administration
Bureau of Radiological Health

Reports

Plutonium-239 in Human Tissues and Bone

Paul J. Magno, Peter E. Kauffman and *Paul R. Groulx* [1]

An average concentration of $7\times10^{-11}\mu$Ci ^{239}Pu/g was found in human bone samples ranging in age from 2 to 24 years. This concentration results in an average dose equivalent rate to bone of about 0.3×10^{-4} rem/year. An average concentration of $7\times10^{-10}\mu$Ci ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. These figures were compared to the Federal Radiation Council's Radiation Protection Guides and the dose limits recommended by the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection. From the data in this report, it was concluded that the concentrations of plutonium-239 in body tissue result in average equivalent dose rates well below the suggested radiation protection guides and dose limits.

Radioisotopes of plutonium have been introduced into the environment during nuclear weapons testing and also from the burnup of a satellite which used plutonium as a power source (*1*, *2*). The Bureau of Radiological Health initiated a program in July 1965 at the Northeastern Radiological Health Laboratory (NERHL) to determine the environmental concentrations of plutonium. The results of measurements of the radioisotopes of plutonium in air, milk, and total diet, have been previously reported (*3–5*); the concentrations of plutonium–239 in human tissues and bone are presented in this report.

[1] Mr. Magno is chief, Environmental Methods and Surveillance Section, Northeastern Radiological Health Laboratory, Bureau of Radiological Health, Winchester, Mass. 01890. Mr. Kauffman was formerly acting chief, Analytical Quality Control Service, NERHL, and is now a research chemist, Food Protection Research Laboratory, Bureau of Community Environmental Management, 222 E. Central Parkway, Cincinnati, Ohio. Mr. Groulx is a physical science technician at the Northeastern Radiological Health Laboratory.

Analytical methodology

Soft tissue samples were solubilized by wet ash with a mixture of nitric and perchloric acids. Plutonium–236 tracer was added, the plutonium was reduced to the +3 oxidation state with hydroxylamine hydrochloride and coprecipitated with the alkaline earth phosphates by addition of ammonium hydroxide. The alkaline earth phosphate precipitate was dissolved in 7.2 M nitric acid and the plutonium oxidized to the +4 oxidation state with sodium nitrite. Bone samples were solubilized by ashing at 800°C., plutonium–236 tracer was added and the ash dissolved in 7.2 M nitric acid.

The nitric acid solution of each sample was then passed over an anion exchange resin in the nitrate form. The resin was washed with additional 7.2 M nitric acid and then with 9 M hydrochloric acid. The plutonium was eluted from the resin with a mixture of 0.36 M hydrochloric acid and 0.01 M hydrofluoric acid, electroplated onto a stainless steel planchet from a sulfuric acid-ammonium electrolyte, and counted in an alpha-particle spectrometer.

The energies of the alpha particles from plutonium–239 and plutonium–240 are not sufficiently different to be separated by alpha particle spectrometry. Therefore, when plutonium–239 is referred to in this report, it represents the sum of the radioactivity of plutonium–239 and plutonium–240.

The samples were usually counted for at least 1,000 minutes. Reagent blanks containing plutonium–236 tracer were run concurrently with the samples. The alpha radioactivity of plutonium–239 was converted to picocuries of the radioisotope per sample by means of the following equation:

$$^{239}\mathrm{Pu} = \frac{(A-B)C}{(D-E)}$$

where,

A = gross counts per minute (CPM) in plutonium-239 spectral region;
B = reagent blank counts per minute in plutonium-239 spectral region;
C = pCi plutonium-236 added;
D = gross counts per minute in plutonium-236 spectral region; and
E = background counts per minute in plutonium-236 spectral region.

A silicon surface barrier detector with an active area of 4.5 cm^2 was used. With the sample electroplated onto a 3.1 cm^2 area, the counting efficiency for plutonium–239 and plutonium–236 was ~31 percent and the resolution was 75 keV (FWHM) [2].

Results

Table 1 presents the results of the analyses of plutonium–239 in human liver and lung samples obtained from autopsies in the Boston, Mass. area during the period August 1965 to February 1967. The plutonium–239 concentrations in the liver samples ranged from 0.21 to 2.52 pCi/kg with a mean value of 0.76 pCi/kg; the lung concentrations ranged from 0.13 to 1.13 pCi/kg with a mean value of 0.43 pCi/kg. Samples of spleen, heart, kidney, and bone were also obtained during some of these autopsies but plutonium–239 was not detected in any of these organs.

Table 1. Plutonium-239 in human liver and lung samples collected from Boston, Mass.

Subject		Date of death	Plutonium-239 (pCi/kg) [a]	
Age	Sex		Liver	Lung
73	M	8/65	0.25±0.04	0.23±0.07
66	F	8/65	.36± .08	.23± .08
58	F	8/65	.37± .13	.48± .11
52	F	8/65	NS	.74± .21
80	F	8/65	2.52± .56	1.13± .17
47	M	10/65	NS	.14± .04
76	F	11/65	.69± .10	.34± .06
70	F	1/66	.21± .04	.17± .09
80	M	3/66	.83± .13	.45± .09
63	M	6/66	.60± .11	.33± .07
65	M	6/66	1.20± .13	.42± .09
58	M	6/66	1.31± .09	.74± .14
54	M	7/66	.31± .08	.41± .11
59	M	7/66	.63± .07	.55± .21
83	M	9/66	.86± .14	.13± .03
63	M	2/67	.45± .11	.39± .09

[a] Two sigma counting error.
NS, no sample obtained.

Table 2 presents the results of the analyses of plutonium–239 in human liver and lung samples collected from other areas in the United States during the period September 1966 to January 1967. The plutonium–239 concentrations in these liver samples ranged from 0.31 to 1.14 pCi/kg with a mean value of 0.69 pCi/kg; the lung concentrations ranged from 0.17 to 0.94 pCi/kg with a mean value of 0.41 pCi/kg.

Table 2. Plutonium-239 in human liver and lung samples collected from various areas in the United States

Subject		Date of death	Collection location	Plutonium-239 (pCi/kg)[a]	
Age	Sex			Liver	Lung
71	F	9/66	Portland, Ore.	0.31±0.08	0.35±0.09
54	M	10/66	Indianapolis, Ind.	.52± .13	.24± .09
72	F	11/66	Colorado Springs, Colo.	.86± .17	.94± .19
62	F	11/66	Palo Alto, Calif.	.87± .11	.17± .06
49	M	11/66	Butte, Mont.	1.14± .26	.55± .12
62	M	1/67	New Orleans, La.	.46± .09	.21± .08

[a] Two sigma counting error.

Bone samples of sufficient size for detection of plutonium–239 could not be obtained during the autopsies from which the soft tissue samples were collected. Therefore, in order to develop information on the concentrations of plutonium–239 in human bone, a series of composite

[2] (FWHM), full width at half maximum.

bone ash samples (vertebrae) containing 150 to 300 grams of ash were analyzed and the results are presented in table 3. These samples were collected during the period, 1964–1966, and were composited according to the area of collection and the age groups used in evaluating the results of analyses of strontium–90 in human bone. (*5*). The concentration of plutonium–239 bones from the 2 to 4-year and 5 to 9-year age groups was higher than that of other age groups.

Table 3. Plutonium-239 in human bone composite samples

Age group	Region	Year collected	Plutonium-239 concentration	
			(pCi/kg ash)[a]	(pCi/kg wet bone)[a]
2–4	Central	1964	0.79 ±0.16	0.080 ±0.016
	Northeast	1965	.85 ± .18	.073 ± .015
5–9	Central	1964	1.4 ± .3	.12 ± .03
	Central	1965	.84 ± .22	.078 ± .021
	Northeast	1965	.82 ± .13	.084 ± .014
	Northeast	1965	1.1 ± .2	.11 ± .02
	Northeast	1966	1.6 ± .3	.16 ± .03
10–14	Northeast	1965	.44 ± .11	.046 ± .012
	Central	1965	.59 ± .12	.072 ± .014
15–19	Central	1964	.32 ± .13	.043 ± .018
	Central	1965	.27 ± .09	.039 ± .013
	Central	1965	.35 ± .12	.042 ± .014
	Northeast	1965	.41 ± .10	.047 ± .011
	Northeast	1965	.41 ± .09	.058 ± .013
	Northeast	1966	.75 ± .24	.082 ± .026
20–24	Central	1965	.41 ± .09	.067 ± .015
	Central	1965	.40 ± .10	.064 ± .016
	Northeast	1965	.41 ± .11	.050 ± .014
	Northeast	1965	.55 ± .13	.072 ± .017

[a] Two sigma counting error.

One of the objectives of this study was to develop information on the distribution of plutonium in the human body with particular emphasis on the relationship between plutonium–239 in the liver and in the bone. This requires a comparison of data for soft tissue and bone samples from the same individuals. Therefore, liver, lungs, spleens, and large samples of femur were obtained from three cadavers in the Boston, Mass. area. The results of the analyses of these samples are presented in table 4.

Unfortunately, the plutonium–239 concentration in these femurs was below the detection limit and the only observation that can

Table 4. Plutonium-239 in human soft tissue and bone samples collected in Boston, 1963–1965

Subject		Date of death	Organ	Plutonium-239	
Age	Sex			(pCi)	(pCi/kg)[a,b]
75	F	10/63	Liver (whole)	[b] 0.41 ±0.06	0.24 ±0.04
			Spleen (whole)	[c] .010 ± .011	[c] .067 ± .073
			Lung (right)	.064 ± .022	.13 ± .04
			Femur (400 g)	[c] .005 ± .010	[c] .013 ± .025
77	F	10/64	Liver (whole)	.77 ± .10	.45 ± .06
			Spleen (whole)	[c] .000 ± .008	[c] .000 ± .053
			Lung (right)	.30 ± .05	.60 ± .10
			Femur (455 g)	[c] .008 ± .010	.018 ± .022
73	F	10/65	Liver (whole)	.93 ± .12	.55 ± .07
			Spleen (whole)	[c] .007 ± .010	[c] .049 ± .065
			Lung (right)	.29 ± .07	.58 ± .14
			Femur (400 g)	[c] .005 ± .010	[c] .013 ± .025

[a] Two sigma counting error.
[b] Based on the weight of the organ in standard man except for the femur.
[c] Not significant data but used for averaging purposes.

be made from these data concerning the bone-liver relationship is that the concentration of plutonium–239/kg of femur of these individuals was lower than the liver by a factor of at least 10. The availability of bone samples of sufficient size for analysis of plutonium is the limiting factor in using individual autopsies to establish the bone to liver relationship from environmental exposures. Either very large representative bone samples must be obtained (this is very difficult) or more sensitive and sophisticated analytical techniques must be applied.

Conclusions

An average concentration of 7×10^{-11} μCi ^{239}Pu/g was found in bone collected from individuals ranging in age from 2 to 24 years. This concentration [3] results in an average dose equivalent rate to bone of about 3×10^{-4} rem/year. An average concentration of 7×10^{-10} μCi ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. The formula for dose rate calculations for these organs is given in reference (*6*). The Federal Radiation Coun-

[3] Doses were calculated assuming homogeneous distribution of the radionuclide throughout the organ.

cil (FRC) (*7*) recommends a Radiation Protection Guide for bone of 1.5 rem/year for individuals in the general population and 0.5 rem/year as an average to be applied to suitable samples of an exposed population group. The FRC (*9*) has not recommended a Radiation Protection Guide for liver. The National Council on Radiation Protection and Measurements (*9*) and the International Commission on Radiological Protection (*10*) recommend a dose limit for individual members of the public of 1.5 rem/year for liver.

From the data presented in this report, it can be concluded that the concentrations of plutonium–239 present in body tissues result in average dose equivalent rates well below the suggested radiation protection guides and dose limits.

Acknowledgement

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SECTION I. MILK AND FOOD

Milk Surveillance, October 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides occurring or formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere reported in *Radiological Health Data and Reports*

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. As a result of a study made of the PMN results for calcium content in milk for the period, May 1963–March 1966, an average value for the PMN and its two standard deviation, 1.16 ± 0.08 g/liter, was developed as an appropriate calcium content in milk for use in general radiological health calculations or discussions (*3*). As a result of a parallel study, an average value for the PMN, 1.51 ± 0.21 g/liter, for potassium content in milk was developed (*3*).

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131, and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3 standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error because of disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy on whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical and is generally increased at the first

measurement of recognition of a new influx of the radionuclide.

Also reflected in the data presentation is whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine–131	4–10 pCi/liter for levels <100 pCi/liter; 6–10% for levels ≥100 pCi/liter
Cesium–137	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter
Barium–140	5–10 pCi/liter at levels <100 pCi/liter; 6–10% for levels ≥100 pCi/liter

For iodine–131, cesium–137, and barium–140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8–9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	1.5	0.5	[c] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[c] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[d]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants

[b] Based on an average intake of 1 liter of milk per day.

[c] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third of the respective RPG.

[d] The guides expressed here were not given in the FRC reports, but were calculated using appropropriate FRC recommendations.

from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10–11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in ex-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels following an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	4	9	0(5)	0	12(5)	13
Alaska:	Palmer[c]	P	7	6	0(2)	0	20(2)	14
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	2
Ark:	Little Rock[c]	P	20	21	0(4)	0	22(4)	20
Calif:	Sacramento[c]	P	4	3	0(4)	0	6(4)	6
	San Francisco[c]	P	0	1	0(5)	0	0(5)	5
	Del Norte	P	19	19	0	0	31	23
	Fresno	P	0	0	0	0	0	5
	Humboldt	P	0	3	0	0	21	10
	Los Angeles	P	0	0	0	0	16	7
	Mendocino	P	0	3	0	0	0	4
	Sacramento	P	5	2	0	0	0	6
	San Diego	P	0	0	0	0	0	2
	Santa Clara	P	0	0	0	0	0	7
	Shasta	P	4	3	0	0	11	4
	Sonoma	P	0	2	0	0	0	5
Colo:	Denver[c]	P	6	4	0(5)	0	5(5)	6
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		(e)(2)	3	(e)(2)	(e)
	East	R	(d)		(e)	(e)	(e)	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	4	10	0(4)	0	10(4)	11
	Central	R	7	8	0(4)	0	11(4)	9
Del:	Wilmington[c]	P	6	10	0(5)	0	0(5)	8
D.C.:	Washington[c]	P	8	10	0(4)	0	3(4)	6
Fla:	Tampa[c]	P	8	8	0(5)	0	75(5)	66
	West	R	11	15	0	3	28	25
	North	R	18	16	0	3	40	26
	Northeast	R	10	9	0	2	84	84
	Central	R	6	10	0	8	64	103
	Tampa Bay area	R	6	8	0	0	90	74
	Southeast	R	9	9	0	2	191	109
Ga:	Atlanta	P	12	14	0(5)	0	18(5)	20
Hawaii:	Honolulu[c]	P	6	4	0(4)	1	0(4)	4
Idaho	Idaho Falls[c]	P	4	5	0(4)	0	3(4)	8
Ill:	Chicago[c]	P	9	9	0(4)	0	10(4)	10
Ind:	Indianapolis[c]	P	9	8	0	0	2(4)	7
	Northeast	P	9	9	0	0	15	10
	Southeast	P	10	10	0	0	0	12
	Central	P	9	8	0	0	18	9
	Southwest	P	6	9	0	0	0	13
	Northwest	P	11	9	0	0	12	11
Iowa:	Des Moines[c]	P	9	7	0(5)	0	10(5)	7
	Iowa City	P	5(2)	7	0(2)	0	7(2)	4
	Des Moines	P	5(4)	7	0(4)	0	0(4)	2
	Spencer	P	6	7	0	0	10	4
	Charles City	P	NS	NS	NS	0	NS	NS
Kans:	Wichita[c]	P	8	8	0(4)	0	0(4)	5
Ky:	Louisville[c]	P	12	12	0(4)	0	15(4)	6
La:	New Orleans[c]	P	19	20	0(4)	0	22(4)	23
Maine:	Portland[c]	P	7	12	0(4)	0	25(4)	28
Md:	Baltimore[c]	P	9	10	0(5)	0	6(5)	7
Mass:	Boston[c]	P	7	12	0(5)	0	19(5)	24
Mich:	Detroit[c]	P	6	9	0(5)	0	7(5)	12
	Grand Rapids[c]	P	6	10	0(4)	0	10(4)	15
	Bay City	P	NS	4	NS	(e)	NS	5
	Charlevoix	P	NS	5	NS	(e)	NS	7
	Detroit	P	2(2)	4	(e)	(e)	0	4
	Grand Rapids	P	4	5	(e)	(e)	0	8
	Lansing	P	4(2)	4	(e)	(e)	0	2
	Marquette	P	6	7	(e)	(e)	20	21
	Monroe	P	3	4	(e)	(e)	0	2
Minn:	Minneapolis[c]	P	12	12	0(4)	0	9(4)	12
	Bemidji	P	14	15	0	0	23	21
	Mankato	P	7	6	0	0	0	0
	Rochester	P	11	8	0	0	0	0
	Duluth	P	19	20	0	0	27	29
	Worthington	P	6	6	0	0	0	0
	Minneapolis	P	10	12	0	0	34	12
	Fergus Falls	P	9	9	0	0	13	0
	Little Falls	P	9	9	0	0	12	13
Miss:	Jackson[c]	P	17	17	0(4)	0	16(4)	14
Mo:	Kansas City[c]	P	11	8	0(4)	0	3(4)	5
	St. Louis[c]	P	8	9	0(4)	0	6(4)	8
Mont:	Helena[c]	P	NA	5	0(5)	0	3(5)	8
Nebr:	Omaha[c]	P	5	7	0(4)	0	9(4)	5
Nev:	Las Vegas[c]	P	0	1	0(5)	0	0(5)	4
N.H.:	Manchester[c]	P	11	14	0(5)	0	28(5)	36
N.J.:	Trenton[c]	P	6	10	0(5)	0	5(5)	11
N.Mex:	Albuquerque[c]	P	4	2	0(5)	0	0(5)	2

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	NA	9	0(4)	0	3(4)	10
	New York City[c]	P	7	12	0(4)	0	14(4)	15
	Syracuse[c]	P	8	9	0(4)	0	3(4)	5
	Albany	P	NA	NA	NA	NA	NA	NA
	Buffalo	P	NA	NA	NA	NA	NA	NA
	Massena	P	NA	NA	NA	NA	NA	NA
	Newburg	P	NA	NA	NA	NA	NA	NA
	New York City	P	NA	NA	NA	NA	NA	NA
	Syracuse	P	NA	NA	NA	NA	NA	NA
N.C.:	Charlotte[c]	P	18	15	0(5)	1	12(5)	12
N.Dak:	Minot[c]	P	11	11	0(4)	0	11(4)	13
Ohio:	Cincinnati[c]	P	6	9	0(5)	0	0(5)	6
	Cleveland[c]	P	6	10	0(4)	0	0(4)	9
Okla:	Oklahoma City[c]	P	10	10	0(4)	0	8(4)	4
	Oklahoma City	P	(d)		NA	NA	NA	NA
	Enid	P	(d)		NA	NA	NA	NA
	Tulsa	P	(d)		NA	NA	NA	NA
	Lawton	P	(d)		NA	NA	NA	NA
	Ardmore	P	(d)		NA	NA	NA	NA
Ore:	Portland[c]	P	9	7	0(4)	0	10(4)	15
	Baker	P	NS	6	(e)	(e)	(e)	4
	Coos Bay	P	NS	10	(e)	(e)	22	14
	Eugene	P	NS	3	(e)	(e)	(e)	11
	Medford	P	NS	3	(e)	(e)	60	15
	Corvallis	P	NS	NS	(e)	(e)	(e)	3
	Portland composite	P	NS	7	(e)	(e)	(e)(4)	8
	Portland local	P	NS	6	(e)	(e)	11(4)	13
	Redmond	P	NS	4	(e)	(e)	(e)	8
	Tillamook	R	NS	10	(e)	(e)	25	26
	Albany	P	NS	NS	(e)	(e)	(e)	3
Pa:	Philadelphia[c]	P	6	10	0(4)	0	3(4)	9
	Pittsburgh[c]	P	8	12	0(5)	0	4(5)	13
	Dauphin	P	9	8	0	0	0(2)	17
	Erie	P	15	13	0	0	18(2)	22
	Philadelphia	P	7	9	0	0	15(2)	17
	Pittsburgh	P	8	12	0	0	13(4)	15
R.I.:	Providence[c]	P	8	11	0(5)	0	17(5)	18
S.C.:	Charleston[c]	P	16	14	0(5)	0	25(5)	26
S.Dak:	Rapid City[c]	P	8	10	0(4)	0	2(4)	10
Tenn:	Chattanooga[c]	P	12	13	0(4)	0	12(4)	13
	Memphis[c]	P	12	11	0(5)	0	0(5)	4
	Chattanooga	P	11	13	0(4)	1	3(4)	17
	Clinton	P	14	13	0	2	11	20
	Knoxville	P	10	12	0	4	0	15
	Nashville	P	8	8	0	1	0	14
Tex:	Austin[c]	P	0	3	0(3)	0	4(3)	2
	Dallas[c]	P	8	8	0(4)	0	5(4)	5
	Amarillo	R	NA	5	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	0
	El Paso	R	NA	1	NA	0	NA	0
	Fort Worth	R	NA	7	NA	0	NA	0
	Harlingen	R	NA	2	NA	0	NA	0
	Houston	R	NA	10	NA	0	NA	10
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	4	NA	0	NA	0
	San Antonio	R	NA	3	NA	0	NA	0
	Texarkana	R	NA	11	NA	0	NA	10
	Uvalde	R	NA	3	NA	0	NA	0
	Wichita Falls	R	NA	9	NA	0	NA	0
Utah:	Salt Lake City[c]	P	6	6	0(5)	0	7(5)	12
Vt:	Burlington[c]	P	6	11	0(5)	0	8(5)	9
Va:	Norfolk[c]	P	15	11	0(4)	0	7(4)	9
Wash:	Seattle[c]	P	10	9	0(5)	0	23(5)	21
	Spokane[c]	P	NA	7	0(5)	0	4(5)	10
	Benton County	R	NS	0	NS	0	NS	3
	Deer Park	R	5	3	0	0	(e)	2
	Elma	R	7	4	0	0	(e)	20
	Franklin County	R	0	0	0	0	(e)	(e)
	Moses Lake	R	3	1	0	0	(e)	(e)
	Pierce County	R	4	3	0	0	(e)	8
	Sandpoint, Idaho	R	11	7	0	0	28	22
	Skagit County	R	8	4	0	0	24	15
W.Va:	Charleston[c]	P	9	12	0(5)	0	6(5)	5
Wisc:	Milwaukee[c]	P	5	8	0(3)	0	14(3)	11
Wyo:	Laramie[c]	P	5	4	0(5)	0	12(5)	7
CANADA:								
Alberta:	Calgary	R	7	9	(d)		20	19
	Edmonton	R	8	8	(d)		21	22
British Columbia:	Vancouver	R	14	14	(d)		48	51

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)							
Manitoba: Winnipeg	R	8	8	(d)		27	25
New Brunswick: Fredericton	R	18	15	(d)		26	25
Newfoundland: St. Johns	R	19	21	(d)		43	42
Nova Scotia: Halifax	R	10	12	(d)		21	24
Ontario: Ft. William	R	15	16	(d)		30	29
Ottawa	R	7	9	(d)		20	20
Sault Ste. Marie	R	15	15	(d)		40	32
Toronto	R	4	5	(d)		21	16
Windsor	R	6	5	(d)		11	14
Quebec: Montreal	R	11	10	(d)		18	21
Quebec	R	12	13	(d)		28	28
Saskatchewan: Regina	R	8	8	(d)		20	16
Saskatoon	R	11	9	(d)		20	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	0	1	0	0	0	2
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Kingston	P	4	5	0	0	80	120
Venezuela Caracas	P	NS		NS		NS	
Canal Zone: Cristobal[e]	P	4	2	0(4)	1	20(4)	10
Puerto Rico: San Juan[e]	P	5	5	0(4)	0	11(4)	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado, 25 pCi/liter; Michigan, 14 pCi/liter; Oregon, 15 pCi/liter.
Cesium-137: Colorado, 25 pCi/liter; New York, 20 pCi/liter; Oregon, 15 pCi/liter; Washington, 15 pCi/liter.
Strontium-90: New York, 3 pCi/liter

NA, no analysis.
NS, no sample collected.

posure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable, a more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages that are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

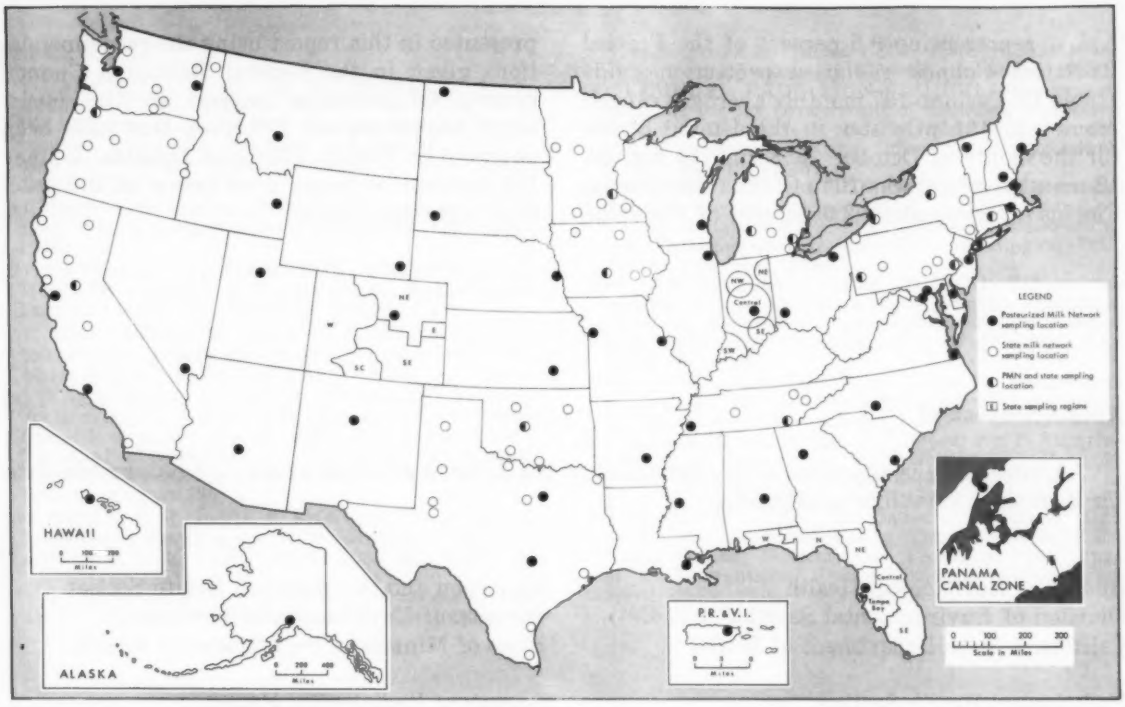

Figure 2. State and PMN milk sampling locations in the United States

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Table 4. Monthly average of strontium–89 and barium–140 in milk, October 1968

Sampling location	Radionuclide concentration (pCi/liter)	
	Strontium-89	Barium-140
Nebraska, Omaha (PMN)	7	
Canal Zone, Cristobal (PMN)	8	
Colombia: Bogota (PAHO)	15	
Chile: Santiago (PAHO)	10	
Ecuador: Guayaquil (PAHO)	10	
Iowa: Des Moines (PMN)		2(5)
Oregon: Portland (PMN)		3(4)
Rhode Island: Providence (PMN)		3(5)

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131, and cesium–137 for October 1968 and the 12-month period, November 1967–October 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–140 data have been omitted from table 3 since levels at the great majority of the stations for October 1968 were below the respective practical reporting levels with the exception of stations given in table 4.

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine–131 are numerically equal to the upper value of Range 1 (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 20 pCi/liter in the United States for the month of October 1968 and the highest 12-month average was 21 pCi/liter (Little Rock,

Ark.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 191 pCi/liter in the United States for the month of October 1968 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 monthly averages were below all the practical reporting levels.

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Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Institutional Diet	April–June 1968	January 1969
Tri-City Diet, HASL	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968
Washington	July 1966–June 1967	August 1968

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Gross Radioactivity in Surface Waters of the United States, August 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A dis-

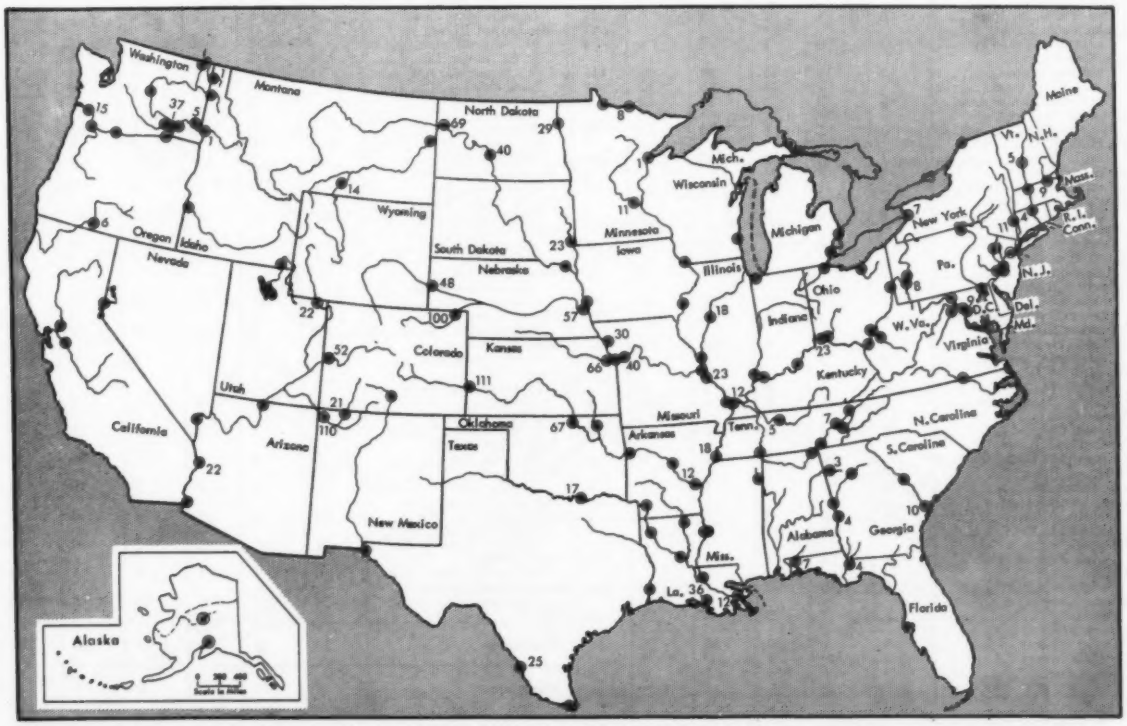

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, August 1968

cussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During August 1968, the following stations showed values in excess of 15 pCi/liter of alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
Missouri River; Williston, N. Dak.
San Juan River; Shiprock, N. Mex.
South Platte River; Julesburg, Colo.

During this month no station showed beta radioactivity in excess of 150 pCi/liter on suspended or dissolved solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, August 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	6	1	7	15	6	21
Apalachicola River:						
Chattahoochee, Fla.	1	0	1	0	4	4
Arkansas River:						
Coolidge, Kans.	17	19	36	59	52	111
Ponca City, Okla.	13	1	14	55	12	67
Pendleton Ferry, Ark.	0	3	3	0	12	12
Atchafalaya River:						
Morgan City, La.	7	1	8	25	11	36
Big Horn River:						
Hardin, Mont.	1	5	6	2	12	14
Big Sioux River:						
Sioux Falls, S. Dak.	<1	1	1	2	21	23
Chattahoochee River:						
Columbus, Ga.	0	0	0	1	3	4
Clearwater River:						
Lewiston, Idaho	0	0	0	<1	1	1
Clinch River:						
Kingston, Tenn.[a]	0	0	0	0	7	7
Colorado River:						
Loma, Colo.	11	8	19	39	13	52
Parker Dam, Calif-Ariz.	0	4	4	0	22	22
Columbia River:						
Pasco, Wash.[a]	0	0	0	13	24	37
Clatskanie, Ore.	0	1	1	6	9	15
Connecticut River:						
Wilder, Vt.	0	0	0	2	3	5
Enfield Dam, Conn.	0	1	1	1	3	4
Coosa River:						
Rome, Ga.	0	1	1	0	3	3
Cumberland River:						
Cheatham Lock, Tenn.	1	0	1	2	3	5
Escambia River:						
Century, Fla.	0	0	0	3	4	7
Great Lakes:						
Duluth, Minn.	0	0	0	0	1	1
Buffalo, N.Y.	0	1	1	0	7	7
Green River:						
Dutch John, Utah	0	3	3	<1	22	22
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	1	10	11
Illinois River:						
Peoria, Ill.	1	1	2	6	12	18
Kansas River:						
DeSoto, Kans.	9	1	10	53	13	66
Klamath River:						
Keno, Ore.	0	<1	<1	<1	6	6
Merrimack River:						
Lowell, Mass.	1	0	1	4	5	9
Mississippi River:						
St. Paul, Minn.	1	3	4	1	10	11
E. St. Louis, Ill.	3	1	4	14	9	23
W. Memphis, Ark.	2	1	3	9	9	18
New Orleans, La.	1	1	2	3	9	12
Missouri River:						
Williston, N. Dak.	16	9	25	56	13	69
Bismarck, N. Dak.	0	3	3	2	38	40
St. Joseph, Mo.	2	2	4	12	18	30
Missouri City, Mo.	4	1	5	21	19	40
Monongahela River:						
Pittsburgh, Pa.	0	1	1	1	7	8
North Platte River:						
Henry, Nebr.	2	14	16	5	43	48
Ohio River:						
Cincinnati, Ohio	0	0	0	3	20	23
Cairo, Ill.	1	0	1	3	9	12
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	0	1	1
Platte River:						
Plattsmouth, Nebr.	10	3	13	35	22	57
Potomac River:						
Washington, D.C.	1	2	3	3	6	9
Rainy River:						
International Falls, Minn.	0	0	0	1	7	8
Red River, North:						
Grand Forks, N. Dak.	1	2	3	3	26	29
Red River, South						
Denison, Tex.	0	0	0	2	15	17
Rio Grande:						
Laredo, Tex.	1	3	4	7	18	25
San Juan River:						
Shiprock, N. Mex.	30	2	32	94	16	110
Savannah River:						
Port Wentworth, Ga.[a]	<1	<1	<1	2	8	10
Snake River:						
Wawawai, Wash.	0	1	1	0	5	5
South Platte River:						
Julesburg, Colo.	6	40	46	20	80	100
Maximum	30	40	46	94	80	111
Minimum	0	0	0	0	1	1

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radionuclide Analysis of Coast Guard Water Supplies January-December 1967

U.S. Coast Guard [1] and *Bureau of Radiological Health* [2]

Since 1961, water samples have been collected from seven Coast Guard Loran Stations in Alaska and analyzed for radioactivity. These stations are identified as Adak Island, Attu Island, Biorka Island, Cape Sarichef, Port Clarence, Sitkinak Island, and Spruce Cape. Their locations are shown in figure 1.

The principal source of water for these Loran Stations is either lakes or reservoirs, most of which have ice and snow cover for many of the winter months. Water is piped from the reservoirs to storage tanks at the stations. The storage tanks range in capacity from 25,000 to 225,000 gallons. All of the stations chlorinate the water and all but the Attu Island station filter the water prior to use.

One-gallon samples are collected monthly and sent to the Southwestern Radiological Health Laboratory in Las Vegas, Nev. for analysis. The samples are analyzed routinely for gross alpha and gross beta radioactivity. Samples are also analyzed for specific radionuclides if unusual amounts of gross radioactivity are detected.

Gross alpha and gross beta results for the water samples collected during 1967 are shown in table 1. None were found to contain more

[1] U.S. Department of Transportation.
[2] U.S. Public Health Service.

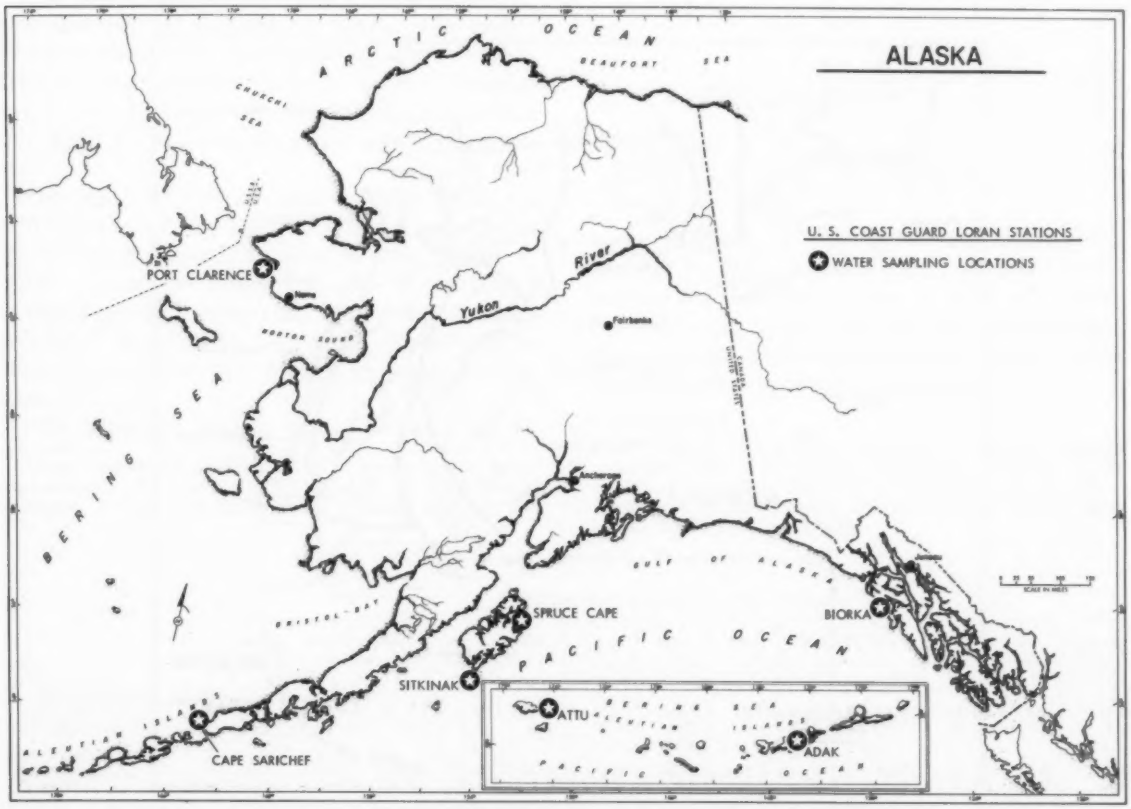

Figure 1. Coast Guard Loran station water sampling locations

Table 1. Radioactivity in water samples from U.S. Coast Guard Loran Stations, January–December 1967

Month (1967)	Adak Island		Attu Island		Biorka Island		Cape Sarichef		Port Clarence		Sitkinak Island		Spruce Cape	
	α	β	α	β	α	β	α	β	α	β	α	β	α	β
January	[a] 0	[a] 0	0	3	0	13	0	8	0	8	NS	NS	0	0
February	0	10	0	5	0	10	0	0	0	10	NS	NS	0	0
March	0	[b] 20	0	0	0	6	0	6	0	0	0	8	0	0
April	0	3	0	4	0	9	0	3	0	18	NS	NS	0	4
May	0	0	0	6	0	9	0	5	0	15	NS	NS	0	7
June	0	3	0	4	0	9	NA	NA	0	9	NS	NS	0	18
July	0	4	NA	NA	0	9	0	4	0	6	0	3	0	3
August	0	3	0	0	0	8	0	0	0	4	NS	NS	0	3
September	0	4	NS	NS	0	6	0	0	0	7	NS	NS	0	0
October	0	4	0	0	NS	NS	0	3	0	8	0	7	0	0
November	0	8	0	0	0	5	0	0	NS	NS	NS	NS	0	3
December	3	8	0	7	0	3	0	7	0	14	NS	NS	0	0

[a] Values equal to or less than 2 pCi/liter gross alpha or gross beta radioactivity are reported as zero.
[b] Strontium-90 concentration was 6 pCi/liter.
NA, no analysis.
NS, no sample received.

than 3 pCi/liter gross alpha. Only six samples contained more than 10 pCi/liter gross beta; Adak Island, 20 pCi/liter (March); Biorka Island, 13 pCi/liter (January); Port Clarence, 18 pCi/liter (April), 15 pCi/liter (May), 14 pCi/liter (December); and Spruce Cape, 18 pCi/liter (June). Of these, only Adak Island had a measureable quantity of strontium–90 (6 pCi/liter).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January-December 1965	November 1966
January-December 1966	November 1967

Figure 1. Hydrological surface subbasins in Florida

Radioactivity in Florida Waters, 1967[1]

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health samples raw surface, ground, and treated water in 13 hydrological subbasins as shown in figure 1. Samples collected on a variable frequency and analyzed for gross alpha and beta radioactivity during 1967 are presented in table 1. Gross alpha and beta radioactivity concentrations of less than 7 pCi/liter and less than 10 pCi/liter, respectively, are not reported.

In addition to sampling being done by the Florida State Board of Health, the Bioenvironmental Engineering Research Laboratory, University of Florida, samples surface, ground and municipal water in Alachua County for gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1967 are summarized in table 2. Gross beta radioactivity above the minimum reported concentration was detected in 26 water samples taken in Alachua County. The 26 samples averaged 14 pCi/liter of gross beta radioactivity.

During 1967, 28 samples out of a total of 396 collected from 199 sampling sites showed gross beta radioactivity greater than the minimum reported concentration. Twenty-four surface, ground, and municipal water samples averaged 23 pCi/liter and four seawater samples averaged 215 pCi/liter of gross beta radioactivity.

The average gross beta radioactivity in water samples is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (*1*). Only one treated and one sea water sample showed gross alpha radioactivity greater than the minimum reported concentration.

[1] Data taken from "Report of Florida Radiological Surveillance Programs, 1967" Bureau of Preventable Diseases, Division of Radiological Health, Jacksonville, Fla.

Table 1. Gross alpha and beta radioactivity in Florida waters, 1967

Location subbasin	Number of samples	Alpha (pCi/liter)	Beta (pCi/liter)
Pardido-Escambia Rivers	10	<7	<10
Choctawatchee River	16	<7	<10
Apalachicola River	14	<7	<10
Ochlockonee-St. Marks Rivers	12	<7	<10
Suwannee River	4	<7	<10
St. Mary's-Nassau Rivers	5	<7	<10
	[a] 1	<7	165.0
St. Johns River	117	<7	<10
	[a] 5	<7	10.0
	[a] 3	<7	11.0
	[a] 2	<7	12.0
	[a] 1	<7	13.0
	[a] 1	<7	16.0
	[a] 1	<7	30.0
	[b] 1	<7	31.0
	[a] 1	<7	45.0
Withlacoochee River	20	<7	<10
Tampa Bay area	31	<7	<10
Peace River	18	<7	<10
	[b] 1	0.0	<10
Kissimmee River	8	<7	<10
	[a] 2	<7	22.0
Florida East Coastal area	39	<7	<10
	[a] 1	<7	15.0
Lower Florida area	73	<7	<10
	[a] 1	<7	10.0
	[c] 1	<7	10.0
	[c] 1	<7	11.0
	[c] 1	<7	12.0
	[c] 1	<7	44.0
	[d] 1	15.0	130.0
	[d] 1	<7	194.0
	[d] 1	<7	223.0
	[d] 1	<7	314.0

[a] Raw surface water.
[b] Treated water.
[c] Raw water supply.
[d] Sea water from Biscayne Bay.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 2. Gross beta radioactivity in Florida water, 1967

Location	Radioactivity concentration (pCi/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Alachua County: (19 sampling locations)													
Maximum	12.2	16.9	5.1	9.7	17.7	27.3	15.6	16.0	10.1	13.5	15.1	9.2	14.0
Average	4.2	5.1	1.9	2.1	5.2	7.1	3.8	5.1	3.2	5.7	6.1	3.3	4.4
City of Gainesville:													
Maximum	6.7	28.7	9.3	20.2	11.4	13.9	11.8	5.1	9.7	12.6	11.4	11.4	12.6
Average	2.8	5.3	1.8	3.8	4.2	4.0	2.6	1.3	2.4	3.4	6.0	4.7	3.5

[a] All beta radioactivity minimum values were of background level.

Radioactivity in Minnesota Municipal Water Supplies[1] January-June 1968

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul, and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

[1] Data and information from "Survey of Environmental Radioactivity, January-June 1968," Publication No. C00-651-64. State of Minnesota Department of Health, University Campus, Minneapolis, Minnesota 55440.

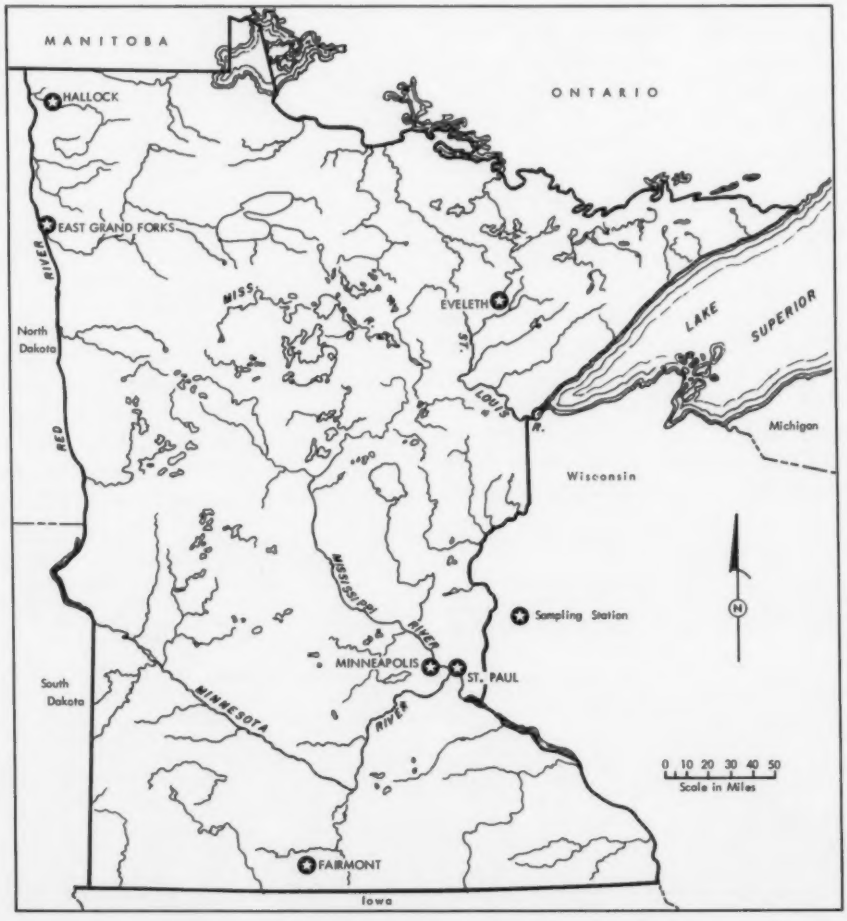

Figure 1. Minnesota surface water sampling locations

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75° C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January-June 1968. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter was considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 5 to 30 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1967	October 1968

Table 1. Total beta radioactivity in Minnesota raw and treated water supplies, January–June 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	22	20	14	16	15	17
	Treated	21	18	18	13	16	17
East Grand Forks, Red Lake River	Raw	15(5)[a]	17(4)	18(4)	13(5)	13(4)	15(4)
	Treated	8(5)	8(4)	10(4)	9(5)	8(4)	19(4)
Eveleth, St. Mary's Lake	Raw	15(5)	13(3)	12(5)	12(4)	13(5)	17(4)
	Treated	12(5)	11(3)	12(5)	14(4)	16(5)	13(4)
Fairmont, Budd Lake	Raw	12(6)	14(5)	13(3)	23(5)	14(5)	14(3)
	Treated	7(6)	5(5)	7(3)	7(5)	10(5)	7(3)
Hallock, Two Rivers South Fork	Raw	20(5)	21(4)	30(4)	15(4)	15(5)	19(4)
	Treated	10(5)	9(4)	12(4)	7(4)	8(5)	10(4)
International Falls, Rainy River	Raw	9	6	6	9	12	5
	Treated	7	8	7	7	8	10
Minneapolis tap water	Raw						
	Treated	5(5)	6(4)	7(4)	7(5)	8(5)	7(4)
St. Cloud, Mississippi River	Raw	9	8	8	10	10	15
	Treated	5	6	5	7	8	7
St. Paul, Vadnais Chain of Lakes	Raw	9(5)	9(4)	10(4)	9(5)	11(4)	12(4)
	Treated	7(5)	5(4)	7(4)	7(5)	6(4)	8(4)

[a] Number in parentheses gives number of samples averaged.

Table 2. Total alpha radioactivity in Minnesota raw and treated water supplies, January–June 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	1	<1	2	8	2	<1
	Treated	<1	<1	1	<1	<1	2
East Grand Forks, Red Lake River	Raw	1(4)[a]	<1(4)	1(4)	2(5)	3(4)	4(4)
	Treated	<1(5)	1(4)	<1(4)	<1(5)	<1(4)	1(4)
Eveleth, St. Mary's Lake	Raw	<1(5)	<1(3)	<1(5)	<1(4)	<1(5)	<1(4)
	Treated	<1(5)	<1(3)	<1(5)	<1(4)	<1(5)	<1(4)
Fairmont, Budd Lake	Raw	4(6)	5(5)	3(3)	4(5)	4(5)	3(3)
	Treated	<1(6)	1(5)	<1(3)	<1(5)	<1(5)	1(3)
Hallock, Two Rivers South Fork	Raw	1(5)	1(4)	<1(4)	2(4)	3(5)	3(4)
	Treated	1(5)	<1(4)	1(4)	<1(4)	<1(5)	<1(4)
International Falls, Rainy River	Raw	<1	<1	<1	<1	1	<1
	Treated	<1	<1	<1	1	<1	<1
Minneapolis tap water	Raw						
	Treated	<1(5)	<1(4)	<1(4)	<1(4)	<1(4)	<1(4)
St. Cloud, Mississippi River	Raw	<1	<1	<1	2	1	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1(5)	1(4)	<1(4)	<1(5)	<1(4)	<1(4)
	Treated	<1(5)	<1(4)	<1(4)	<1(5)	<1(4)	<1(4)

[a] Number in parentheses gives number of samples averaged.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data.* In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network October 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	23	10	0	4	Feb 69	1	40	1	40	37
Alaska:	Adak	31	2	1	2	Feb 69	[c]				
	Anchorage	11	0	0	0	Oct 68	1	8	[d]		
	Attu Island	13	1	0	0	May 68	[c]				
	Fairbanks	[b]				Nov 68	[c]				
	Juneau	22	0	0	0	Dec 68	14	203	14	203	0
	Kodiak	24	1	0	0	Jan 69	[c]				
	Nome	[b]				July 68	[c]				
	Point Barrow	31	4	0	1	June 68	[c]				
	St. Paul Island	31	1	1	1	Aug 68	[c]				
Ariz:	Phoenix	21	15	2	8	Dec 68	[c]				
Ark:	Little Rock	[b]				Oct 68	[c]				
Calif:	Berkeley	23	2	0	1	Jan 69	2	17	2	17	0
	Los Angeles	[b]				July 68	[c]				
C.Z:	Ancon	19	0	0	0	Jan 69	[c]				
Colo:	Denver	22	10	2	4	Jan 69	2	10	[d]		
Conn:	Hartford	22	1	0	0	Nov 68	3	35	3	35	12
Del:	Dover	21	1	0	0	Sept 68	[c]				
D.C.:	Washington	4	0	0	0	June 68	[c]				
Fla:	Jacksonville	23	1	0	1	Oct 68	9	108	9	108	88
	Miami	16	0	0	0	Nov 68	9	215	9	215	0
Ga:	Atlanta	23	2	0	1	Aug 68	2	57	2	57	30
Guam:	Agana	[b]				Sept 68	[c]				
Hawaii:	Honolulu	30	1	0	1	May 68	1	4	[d]		
Idaho:	Boise	23	8	1	5	May 68	4	23	4	23	10
Ill:	Springfield	19	3	0	1	June 68	3	34	0	0	[e]
Ind:	Indianapolis	23	3	0	2	Aug 68	2	15	2	15	22
Iowa:	Iowa City	22	7	0	1	Jan 69	2	53	2	53	0
Kans:	Topeka	23	3	0	1	Oct 68	6	104	6	104	0
Ky:	Frankfort	16	6	0	1	June 68	5	29	5	29	10
La:	New Orleans	22	3	0	1	June 68	5	66	[d]		
Maine:	Augusta	22	2	0	1	Dec 68	7	87	7	87	0
Md:	Baltimore	23	2	0	1	Nov 68	4	35	4	35	6
	Rockville	13	1	0	0	May 68	[c]				
Mass:	Lawrence	21	1	0	0	Sept 68	3	32	3	32	19
	Winchester	23	3	0	1	Feb 69	5	41	5	41	0
Mich:	Lansing	23	5	0	2	May 68	10	41	10	41	74
Minn:	Minneapolis	23	1	0	0	Sept 68	11	160	10	159	14
Miss:	Jackson	21	4	0	1	Dec 68	1	5	1	5	6
Mo:	Jefferson City	22	2	0	1	Aug 68	6	71	6	71	0
Mont:	Helena	21	9	0	3	Feb 69	2	2	2	2	4
Nebr:	Lincoln	21	5	0	2	Aug 68	4	74	3	62	27
Nev:	Las Vegas	19	6	1	3	Nov 68	[c]				
N.H.:	Concord	22	3	0	1	June 68	[c]				
N.J:	Trenton	22	4	0	2	Dec 68	2	23	2	23	7
N. Mex:	Santa Fe	20	1	0	1	Feb 69	3	7	3	7	0
N.Y:	Albany	24	3	0	1	Aug 68	7	57	7	57	43
	Buffalo	22	1	0	1	Jan 69	[c]				
	New York City	22	2	0	1	Feb 69	[c]				
N.C:	Gastonia	18	13	1	6	Jan 69	3	13	[d]		
N. Dak:	Bismarck	21	5	1	2	June 68	[c]				
Ohio:	Cincinnati	[b]				Sept 68	[c]				
	Columbus	20	6	1	2	Dec 68	4	60	0	0	[e]
	Painesville	23	1	0	1	Nov 68	10	12	10	12	7
Okla:	Oklahoma City	19	2	0	1	May 68	2	46	2	46	0
	Ponca City	21	4	1	2	Nov 68	4	56	4	56	7
Ore:	Portland	21	1	0	0	Aug 68	12	101	12	101	0
Pa:	Harrisburg	18	2	0	1	Aug 68	[c]				
P.R:	San Juan	[b]				Dec 68	[c]				
R.I:	Providence	22	2	0	1	May 68	4	34	4	34	9
S.C:	Columbia	21	3	0	1	Feb 69	4	127	4	127	26
S. Dak:	Pierre	5	11	5	7	Dec 68	[c]				
Tenn:	Nashville	20	4	0	1	May 68	5	73	5	73	0
Tex:	Austin	22	10	2	4	Sept 68	3	15	[d]		
	El Paso	21	6	1	3	June 68	[c]				
Utah:	Salt Lake City	29	3	0	2	July 68	3	30	3	30	12
Vt:	Barre	16	5	0	1	Oct 68	8	48	8	48	0
Va:	Richmond	19	1	0	0	Oct 68	1	19	1	19	3
Wash:	Seattle	25	0	0	0	Oct 68	11	57	[d]		
S	Spokane	11	3	0	1	Sept 68	5	20	5	20	11
W. Va:	Charleston	21	2	0	1	Feb 69	5	76	5	76	61
Wisc:	Madison	20	1	0	1	Oct 68	6	152	5	151	76
Wyo:	Cheyenne	23	7	1	3	Nov 68	4	25	4	25	29
Network summary		1,355	15	0	2		4	65	5	57	17

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

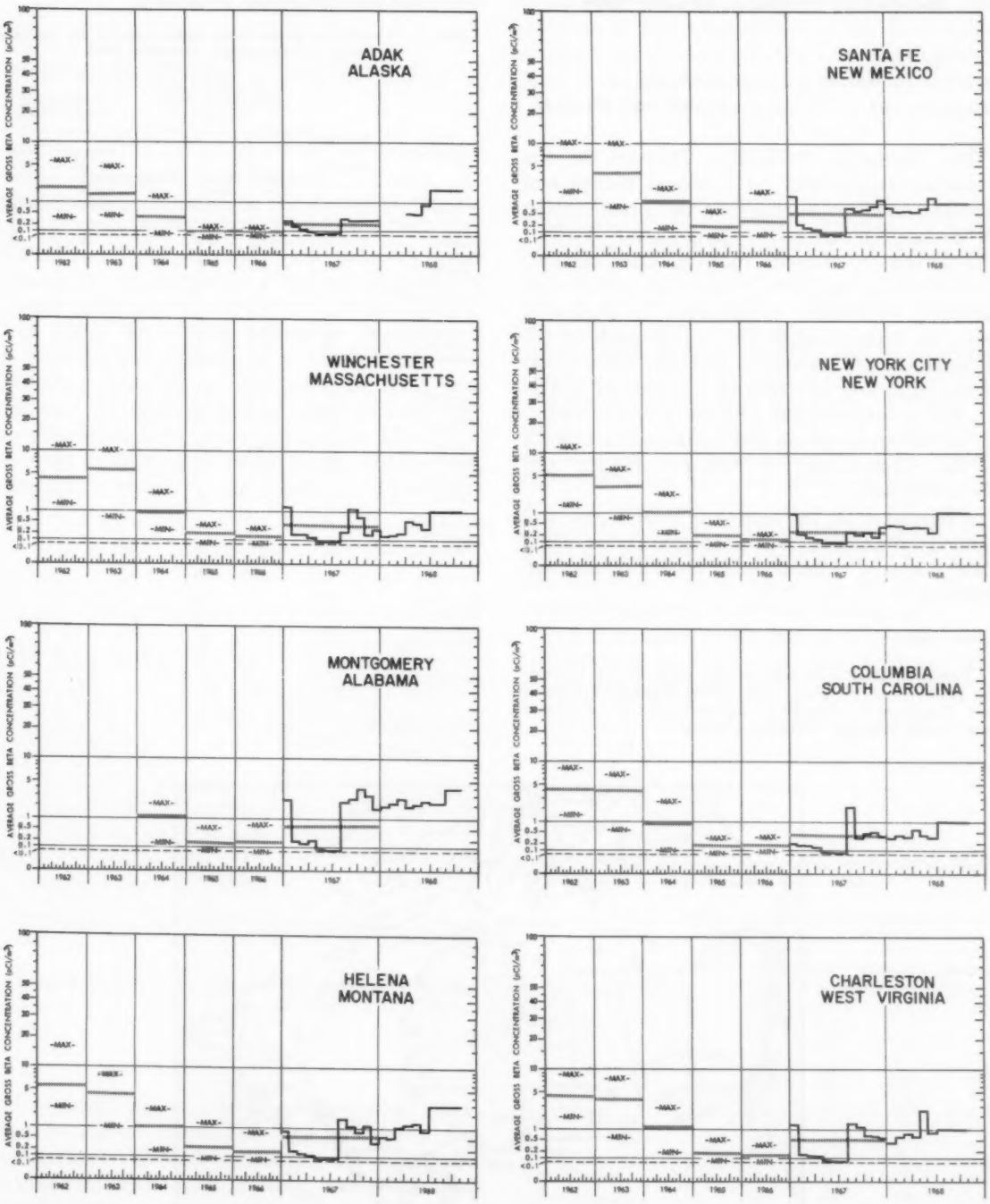

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–October 1968

2. Canadian Air and Precipitation Monitoring Program[1], October 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the November 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for October 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.1	0.0	0.1	NA	NA
Coral Harbour	29	.1	.0	.0		
Edmonton	31	.1	.0	.0		
Ft. Churchill	30	.1	.0	.0		
Ft. William	31	.1	.0	.0		
Fredericton	31	.1	.0	.0		
Goose Bay	29	.1	.0	.0		
Halifax	31	.2	.0	.1		
Inuvik	31	.0	.0	.0		
Montreal	27	.3	.0	.1		
Moosonee	31	.1	.0	.0		
Ottawa	31	.2	.0	.1		
Quebec	31	.1	.0	.0		
Regina	31	.1	.0	.0		
Resolute	29	.1	.0	.0		
St. John's, Nfld	31	.1	.0	.0		
Saskatoon	31	.1	.0	.0		
Saulte Ste. Marie	31	.2	.0	.1		
Toronto	29	.1	.0	.1		
Vancouver	31	.1	.0	.0		
Whitehorse	31	.1	.0	.1		
Windsor	30	.1	.0	.0		
Winnipeg	24	.1	.0	.0		
Yellowknife	31	.1	.0	.0		
Network summary	723	0.3	0.0	0.0	NA	NA

NA, no analysis.

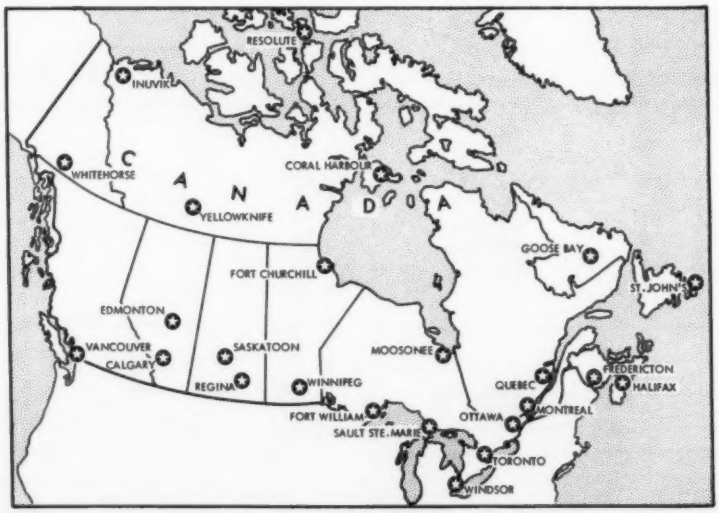

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program June 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4)

Figure 4. Fallout network sampling stations in Mexico

11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during June 1968 are presented in table 3.

Table 3. Mexican gross beta radioactivity of airborne particulates, June 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.7	0.1	0.1
Chihuahua	15	1.1	.1	.3
Ciudad Juárez	15	.8	.1	.3
Ensenada	8	1.7	.1	.4
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	15	.4	.2	.3
Matamoros	NS	NS	NS	NS
Mazatlán	15	.5	.1	.2
Mérida	10	.3	.1	.2
México, D.F.	NS	NS	NS	NS
Nuevo Laredo	NS	NS	NS	NS
San Luis Potosí	NS	NS	NS	NS
Tampico	10	.2	.1	.1
Torreón	19	.3	.1	.2
Veracruz	NS	NS	NS	NS

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program October 1968

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The October 1968 air monitoring results from the participating countries are given in table 4.

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, October 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina:				
Buenos Aires	NS			
Bolivia:				
La Paz	23	2.29	0.10	0.64
Chile:				
Santiago	30	.60	.06	.25
Colombia:				
Bogata	15	.09	.01	.06
Ecuador:				
Guayaquil	22	.64	.15	.34
Guyana:				
Georgetown	NS			
Jamaica:				
Kingston	23	.13	.03	.07
Lima:				
Peru	9	1.16	.32	.64
Venezuela:				
Caracas	19	1.26	.03	.30
West Indies:				
Trinidad	20	.27	.03	.13
Pan American summary	161	2.29	0.01	0.29

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no samples received.

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(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare. Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protective Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comision Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroids, April-June 1968

Bureau of Radiological Health
Public Health Service

The Bureau of Radiological Health established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray spectroscopy for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for July through September 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 11 States during this period. The most active sample analyzed was collected in Garfield County, Colo., on July 30 and contained 44 pCi iodine–131/g thyroid.

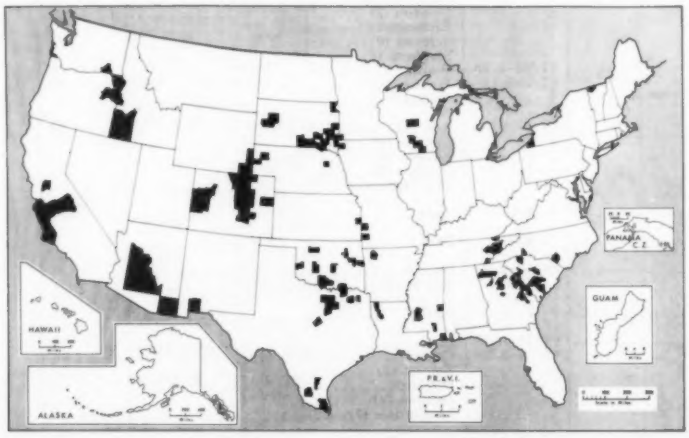

Figure 1. Counties sampled in bovine thyroid network July–September 1968

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October-December 1967	May 1968
January-March 1968	August 1968
April-June 1968	November 1968

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroids, October-December 1964. Radiol Health Data 6:569–571 (October 1965).

Table 1. Iodine-131 in bovine thyroids, July–September 1968

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
Arizona	9/20	Cochise	1	[b] 0		
	*7/12–9/11	Maricopa (14) [d]	18	0		
		Pinal (2)				
		Yavapai (2)				
Arkansas	7/25	Madison	1	0		
California	7/16–9/12	Fresno (1) [d]	26	0		
		Madera (2)				
		Monterey (10)				
		San Benito (10)				
		San L. Obispo (1)				
		San Joaquin (1)				
		Santa Barbara (1)				
Colorado	*7/31–9/30	Adams	7	[b] 0		
	7/17	Arapahoe	1	3		
	*8/15–9/24	Boulder	3	[b] 0		
	7/31	Crowley	1	11		
	*7/16–9/6	Delta	27	[b] 0		
	9/5	Douglas	2	0		
	*7/31–9/25	El Paso	6	2	0	8
	*8/2–9/30	Elbert	2	5	0	10
	*7/30–9/17	Garfield	46	8	0	44
	*7/16–9/27	Jefferson (2) [d]	13	[b] 0		
		Kit Carson (1)				
		Larimer (10)				
	*7/8–9/24	Mesa	35	4	0	22
	*7/23–9/26	Montrose (7) [d]	20	[b] 0		
		Pueblo (2)				
		Teller (1)				
		Weld (10)				
Georgia	*7/2–9/12	Bartow (3) [d]	12	[b] 0		
		Bibb (7)				
		Burke (2)				
	*8/8–9/26	Butts	3	4	0	7
	*7/2–9/12	Candler (7) [d]	32	[b] 0		
		Cherokee (3)		[b] 0		
		Clarke (12)				
		Columbia (2)				
		Emanuel (5)				
		Evans (3)				
	7/31	Floyd	2	3	0	6
	*9/4–9/26	Forsyth	8	2	0	11
	9/25	Fulton	2	14	14	14
	*7/2–9/12	Jasper (2)	22	[b] 0		
		McDuffie (9)				
		Newton (2)				
		Richmond (1)				
		Screven (6)				
		Stephens (2)				
	*7/24–9/26	Walton	6	4	0	10
	*7/2–8/14	Warren (4) [d]	10	[b] 0		
		Wilkes (6)				
Idaho	*7/23–9/28	Ada (11) [d]	32	[b] 0		
		Canyon (9)				
		Elmore (6)				
		Owyhee (3)				
		Washington (3)				
Iowa	9/9	Sioux	8	[b] 0		
Kansas	8/9	Linn	1	0		
Louisiana	*7/31–9/30	Bossier	3	5	0	16
	7/22	Red River	1	0		
Minnesota	7/16	Rock	1	6		
Mississippi	*7/16–7/22		8	0		
	*7/11–8/29	Copiah (2) [d]	22	0		
		Forrest (3)				
		Hinds (6)				
		Jackson (4)				
		Lauderdale (7)				
Missouri	*7/17–8/14	Jasper (2) [d]	3	0		
		Vernon (1)				
Nebraska	9/30	Box Butte	1	14		
	*7/1–9/24	Madison (2) [d]	4	0		
		Scotts Bluff (2)				
New Mexico	9/27	Luna	2	15	13	16
New York	*7/15–8/24	Chautauqua	60	[b] 0		

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, July–September 1968—Continued

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
North Carolina	[c] 8/8–9/17	Cleveland (8) [d]	11	[b] 0		
		Robeson (3)				
Oklahoma	[c] 7/3–7/19		14	0		
	[c] 7/3–7/26	Beckham (2) [d]	5	0		
		Bryan (2)				
		Caddo (1)				
	[c] 7/24–9/28	Carter	6	2	0	11
	[c] 7/3–8/29	Jefferson (3) [d]	23	[b] 0		
		Major (3)				
		Muskogee (3)				
		Pottawatomie (1)				
		Sequoyah (2)				
		Stephens (8)				
		Tulsa (3)				
Oregon	[c] 7/17–9/14	Baker (7) [d]	9	0		
		Wallowa (2)				
South Carolina	7/2–9/17	Bamberg (2) [d]	22	[b] 0		
		Barnwell (3)				
		Colleton (1)				
		Greenwood (3)				
		McCormick (1)				
		Orangeburg 4)				
		Richland (6)				
		Spartanburg (2)				
South Dakota	7/1–9/17	Aurora (3) [d]	15	[b] 0		
		Bon Homme (10)				
		Brookings (2)				
	8/19–9/30	Charles Mix	21	4	0	16
	8/12–9/16	Davison (5) [d]	7	0		
		Gregory (2)				
	7/30–8/7	Hutchinson	13	9	0	27
	7/2–9/25	Lake (1) [c]	33	[b] 0		
		Lincoln (2)				
		McCook (3)				
		Meade (10)				
		Miner (4)				
		Minnehaha (6)				
		Roberts (3)				
		Tripp (4)				
Tennessee	7/2–9/25	Blount (20) [d]	36	[b] 0		
		Claiborne (1)				
		Hamblen (1)				
		Jefferson (3)				
		Knox (11)				
	7/2–9/25	Loudon	8	4	0	12
	9/11	Polk	1	8		
	8/22	Roane	1	10		
	7/24–9/25	Sevier	6	2	0	8
Texas	9/24		3	10	4	14
	[c] 7/19–9/27	Cameron (3) [d]	36	[b] 0		
		Dallas (1)				
		Denton (2)				
		Fannin (1)				
		Hamilton (1)				
		Hopkins (5)				
		Johnson (3)				
		Jim Hogg (10)				
		Jim Wells (3)				
		Tarrant (3)				
		Titus (1)				
		Willacy (2)				
		Wise (1)				
Vermont	[c] 7/3–9/11	Franklin	60	[b] 0		
Washington	[c] 7/30–9/26	Walla Walla	29	0	0	8
Wisconsin	[c] 8/2–9/20	Dane (16) [d]	27	[b] 0		
		Portage (1)				
		Rock (2)				
		Sauk (7)				
		Wood (1)				
Wyoming	[c] 7/23–9/30	Goshen	5	[b] 0		
	[c] 7/16–9/24	Laramie	3	14	4	27

[a] All results ≤ 2 pCi/g are reported as 0 since at these levels of radioactivity, the 2-standard deviation error is 2 pCi iodine-131/g thyroid.

[b] The results for this period were for the most part nondetectable. Some randomly scattered positive results were obtained but these represented barely detectable amounts of iodine-131 in the bovine thyroid (3 to 5 pCi/g).

[c] Samples were not collected on all dates during this period but the interval includes several sampling dates.

[d] Numbers in parentheses represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates or on only one date.

Strontium-90 in Human Bone, October-December 1967[1]

Bureau of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained postmortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but is presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

[1] Period during which death or surgical procedure occurred.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical reproductibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the fourth quarter (October-December 1967) are presented in table 1 in order of increasing age within each geographical region. These

Figure 1. Geographical regions for human bone sampling

Table 1. Human bone network, October–December 1967

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)		Calcium conc. (g/kg bone)	$^{90}Sr/ca$ (pCi/g)
Northeast:	Mass.	V	00	F	89.2	±13.0	26.1	3.41
	N.J.	V	00	M	59.5	10.0	41.8	1.42
	Conn.	R	01	M	115.0	17.0	32.8	3.50
	Mass.	V	02	F	131.0	11.0	37.2	3.52
		V	04	F	148.0	12.0	30.6	4.83
	Conn.	V	04	M	49.5	9.7	28.8	1.71
	Mass.	V	04	F	180.0	13.0	35.2	5.11
		V	04	F	150.0	12.0	36.9	4.06
	N.H.	V	04	F	129.0	14.0	35.3	3.65
	Mass.	V	05	M	61.0	8.6	19.3	3.16
	N.Y.	V	05	M	48.3	8.1	56.9	0.84
		V	05	F	80.3	8.5	32.4	2.47
		V	05	F	133.0	14.0	30.3	4.38
	Conn.	V	06	M	59.2	7.8	29.7	1.99
	N.Y.	V	06	M	91.4	9.7	38.4	2.38
		V	06	M	76.7	7.8	30.5	2.51
	Conn.	V, R	08	M	102.0	10.0	40.3	2.53
	Pa.	V	08	F	88.8	10.0	23.9	3.71
	Mass.	V	09	F	158.0	14.0	37.4	4.22
		V	09	F	54.7	9.2	19.5	2.80
		V	10	F	118.0	13.0	41.4	2.85
		V	11	F	60.8	7.8	33.0	1.84
		V	11	F	97.1	7.8	37.6	2.58
		V	12	M	119.0	9.8	31.8	3.74
		V	13	M	67.9	7.0	28.7	2.36
	N.Y.	V	13	M	61.2	7.2	28.2	2.17
	Conn.	V	14	M	112.0	8.5	44.3	2.52
	Pa.	V	14	F	97.7	10.0	39.2	2.49
	Mass.	V	15	M	177.0	12.0	47.4	3.73
	R.I.	V	15	M	82.9	8.1	45.1	1.83
	Pa.	V	15	M	57.8	7.3	31.8	1.81
	N.Y.	V	16	F	94.8	8.8	53.8	1.76
	Vt.	V	16	M	71.2	7.7	40.5	1.75
	Mass.	V	17	M	170.0	9.9	44.8	3.79
		V	17	M	319.0	20.0	64.8	4.92
	Conn.	V	17	M	99.2	10.0	42.6	2.32
	Vt.	V	18	F	225.0	18.0	61.4	3.66
	N.H.	V	19	F	72.0	7.3	43.9	1.64
	Conn.	V	20	M	70.6	9.6	23.4	3.01
	Mass.	V	21	M	120.0	11.0	60.2	1.99
		V	21	F	100.0	8.8	48.0	2.08
		V	21	M	155.0	14.0	59.3	2.61
		V	21	M	121.0	10.0	54.1	2.23
		V	23	M	83.6	8.8	52.1	1.60
		V	24	M	113.0	10.0	60.5	1.86
	N.Y.	V	24	M	122.0	9.1	46.6	2.61
		V	24	F	90.1	8.8	41.5	2.17
		V	25	F	109.0	9.0	51.4	2.12
	Pa.	V	25	M	79.1	9.5	49.6	1.59
Southeast:	N.C.	V	00	M	185.0	12.0	29.0	6.37
	Ga.	V	00	F	143.0	16.0	24.4	5.86
	S.C.	V	01	M	338.0	24.0	39.3	8.60
	Ala.	V	02	F	92.8	15.0	33.3	2.78
	Md.	V	06	M	135.0	15.0	32.6	4.14
		V	08	M	53.7	9.0	33.5	1.60
		V	12	F	78.8	9.5	37.2	2.11
	S.C.	V	12	M	107.0	8.3	35.7	2.99
		V	13	M	113.0	8.2	28.0	4.03
		V	13	F	83.0	6.8	39.0	2.12
	Md.	V	15	M	141.0	10.0	48.4	2.91
		V	15	M	193.0	15.0	52.6	3.66
		V	17	M	148.0	13.0	56.3	2.62
		V	17	M	134.0	13.0	46.9	2.85
		V	17	M	206.0	18.0	60.4	3.41
	Ga.	V	17	M	244.0	16.0	55.9	4.36
	Md.	V	18	F	86.7	7.8	41.3	2.09
		V	19	M	159.0	10.0	47.6	3.34
		V	19	M	177.0	17.0	68.5	2.58
		V	19	F	133.0	10.0	52.1	2.55
		V	19	M	106.0	10.0	48.3	2.19
	S.C.	V	19	M	153.0	14.0	50.3	3.04
		V	19	F	211.0	14.0	48.3	4.36
	Md.	V	20	M	120.0	11.0	57.2	2.09
		V	20	M	92.2	8.0	45.6	2.02
	Ga.	V	20	M	147.0	13.0	54.4	2.70
	Md.	V	20	M	176.0	15.0	45.3	3.88
	N.C.	V	20	M	132.0	13.0	43.8	3.01
	Ga.	V	20	F	136.0	10.0	54.6	2.49
	Md.	V	21	M	133.0	9.5	50.6	2.62
		V	21	F	95.9	8.6	50.9	1.88
		V	22	M	103.0	11.0	51.8	1.98
	S.C.	V	22	M	107.0	12.0	49.9	2.14
	Md.	V	22	F	367.0	19.0	55.1	6.66
		V	23	M	84.2	8.4	46.5	1.81
	Ga.	V	23	M	86.7	7.8	41.3	2.09
	Md.	V	23	M	156.0	12.0	43.8	3.56
		V	24	M	78.8	7.5	43.0	1.83
	N.C.	V	24	F	97.4	9.9	53.4	1.82
		V	24	M	111.0	9.5	43.1	2.57

See footnotes at end of table.

Table 1. Human bone network, October–December 1967—Continued

Bone region and State	Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)		Calcium conc. (g/kg bone)	^{90}Sr/ca (pCi/g)
Central: Wisc	V	00	M	90.7	17.0	28.5	3.18
	V	00	M	103.0	17.0	32.9	3.13
	V	00	M	56.0	15.0	36.4	1.53
	V	00	M	133.0	19.0	35.1	3.78
	V	01	F	75.7	11.0	27.8	2.72
	V	01	F	69.7	12.0	29.3	2.37
Ohio	V	01	F	107.0	12.0	26.4	4.05
Wisc	V	03	M	117.0	9.4	34.9	3.35
Iowa	V	04	M	87.5	12.0	26.1	3.35
Wisc	V	06	F	133.0	15.0	33.5	3.97
	V	08	F	72.6	7.4	37.7	1.92
	V	09	M	111.0	11.0	29.3	3.78
	V	13	F	80.2	14.0	37.1	2.16
Ohio	V	15	F	160.0	17.0	74.1	2.15
Iowa	V	15	F	75.7	10.0	35.6	2.12
Ohio	V	17	F	116.0	15.0	63.7	1.82
Iowa	V	17	M	60.7	7.0	28.4	2.13
Minn	V	17	M	116.0	12.0	50.0	2.32
Ohio	V	19	F	120.0	10.0	49.8	2.40
	V	19	M	182.0	19.0	80.6	2.25
Mich	V	20	M	110.0	8.5	46.7	2.35
Minn	V	20	M	60.4	6.4	43.5	1.38
Ohio	V	21	M	65.4	7.6	49.1	1.33
Minn	V	21	M	84.1	8.3	53.2	1.58
Ohio	V	21	M	85.9	10.0	72.7	1.18
Delta: La	V, R	07	F	198.0	12.0	44.4	4.45
	V	14	F	123.0	16.0	26.3	4.67
	V, R	18	F	79.3	7.2	53.0	1.49
	V, R	23	F	410.0	21.0	54.2	7.56
Tenn	V	24	M	86.6	9.4	47.5	1.82
Northwest: Ore	V	01	F	101.0	8.1	32.0	3.15
	V	01	M	94.5	8.1	28.2	3.35
	V	01	F	99.9	7.6	31.4	3.18
	V	01	F	165.0	10.0	30.0	5.50
	V	02	F	90.1	6.8	30.7	2.93
	V	07	M	68.2	8.7	33.9	2.01
	V	12	F	56.6	6.5	32.7	1.73
	V	16	M	171.0	12.0	51.4	3.32
	V	17	M	97.4	10.0	48.9	1.91
	V	17	M	116.0	9.5	54.3	2.13
	V	18	M	130.0	10.0	50.0	2.60
	V	18	F	111.0	10.0	51.2	2.16
	V	18	M	101.0	8.6	49.6	2.03
	V	20	M	85.9	7.8	49.5	1.73
	V	21	F	61.4	8.1	51.9	1.18
	V	22	M	52.8	11.0	63.9	0.82
	R	22	M	133.0	19.0	164.0	0.81
	V	23	M	46.3	7.5	53.5	0.86
	V	24	M	76.8	8.4	46.5	1.65
	V	24	F	73.9	9.2	48.6	1.52
	V	24	M	74.2	6.8	47.7	1.55
Alaska	R	17	F	1,330.0	65.0	159.0	8.36
	R	19	M	381.0	35.0	142.0	2.68
	R	24	M	160.0	23.0	129.0	1.24
Southwest: Tex	V	01	M	106.0	16.0	31.2	3.39
	V	01	M	89.5	15.0	26.9	3.32
	V	15	F	97.9	14.0	48.8	2.00
	V	19	M	75.7	12.0	53.4	1.41
	T, FI	23	F	80.2	10.0	62.0	1.29

[a] Type of bone: vertebrae, V; rib, R; tibia, T; fibula, FI.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April-June 1967	September 1968
July-September 1967	October 1968

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Knolls Atomic Power Laboratory and the Shippingport Atomic Power Station.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2] January–December 1967

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the naval reactor program of the AEC in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites; the Knolls site and the Kesselring site, located as shown in figure 1. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and assembly buildings. The Kesselring site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

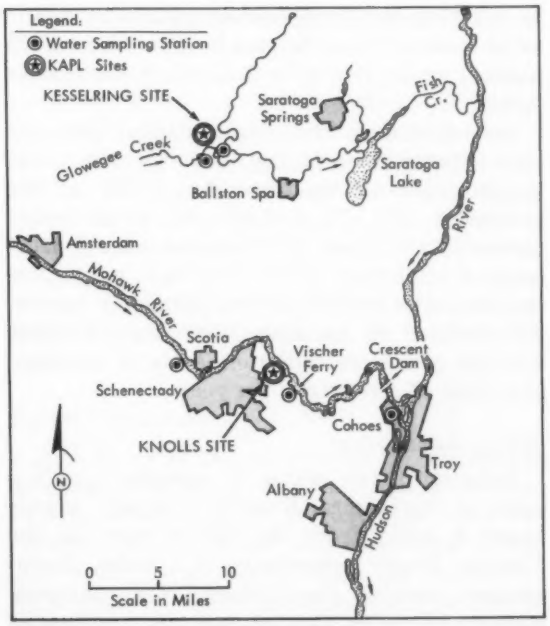

Figure 1. Environmental monitoring locations, KAPL

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site; at one location at the Kesselring site and at the General Electric Company Research Laboratory approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis.

[2] Summaried from "Knolls Atomic Power Laboratory, Annual Environmental Monitoring Report, January-December 1967."

The results of the beta-gamma radioactivity analyses of environmental air show average concentrations of 0.06 pCi/m³ and 0.05 pCi/m³, at the Knolls and offsite sampling locations, respectively. The results were all less than the most restrictive permissible airborne concentration for beta-emitting radionuclides given in AEC Manual Chapter 0524 (strontium–90, 30 pCi/m³). Most of the environmental air results were less than 0.05 pCi/m³, the value considered valid at the 90-percent confidence level with an error of 30 percent. The maximum result (0.17 pCi/m³ was detected at the Knolls site building K–4 location during the first week of March 1967; this was during a period of low-level fallout from Eastern Hemisphere weapons testing. The results of the beta-gamma long-lived radioactivity analyses of air at the Kesselring site showed an average of 0.07 ± 0.02 pCi/m³. Environmental air samples at the Kesselring site are counted a minimum of 48 hours after collection to allow short-lived natural radionuclides to decay to nondetectable levels.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL, at both sites. A perimeter survey of December 1967 showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth of a roentgen per year.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse 8 miles from the Knolls site; at the Vischer Ferry powerhouse 1.7 miles downstream; and at the Cohoes, N.Y. pumping station 13 miles downstream. A continuous sample of Cohoes municiple water, which is derived from river water, is also collected at the Cohoes pumping station. The weekly water samples are composited and analyzed for radioactivity on a monthly basis. Average quarterly beta-gamma concentrations are given in table 1.

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point.

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1967

1967	Beta and gamma radioactivity (pCi/liter)			
	G.E. powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes River water (downstream)	Municipal water
January–March	5±4	8±4	4±4	7±4
April–June	8±4	1±5	3±4	2±4
July–September	3±4	5±4	6±5	2±5
October–December	7±4	6±5	7±5	3±5

The average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid-waste outfalls are shown in table 2.

Table 2. Radioactivity in Glowegee Creek water from the Kesselring site operations, KAPL, January–December 1967

1967	Beta and gamma radioactivity (pCi/liter)	
	Glowegee Creek (upstream)	Glowegee Creek (downstream)
January–March	<4±6	<5±6
April–June	<2±6	<3±6
July–September	<6±6	<6±6
October–December	<1±6	<1±6

Sediment monitoring

Effective May 1, 1967, the Knolls site Mohawk River monitoring program was extended from an annual to a quarterly collection and analyses of Mohawk River sediment. Samples are collected at fifteen specific locations and all are analyzed for gamma, gross beta, and alpha radioactivity content; in addition, three of the samples are analyzed for strontium–90 content.

The variation in the detectable levels of the analyses of Mohawk River sediment is the result of differences in the size of aliquots analyzed, i.e., 10 grams of sediment for alpha radioactivity analysis, 1 gram for beta radioactivity analysis, 10 grams for strontium–90 separation and the total sample for cesium–137 analysis. The Knolls site radioactive liquid waste disposal program did not adversely influence the radioactivity levels of the Mohawk River sediment. The radioactivity concentra-

Table 3. Radioactivity concentrations in Mohawk River sediment, KAPL, 1967

1967	Number of samples	Total radioactivity (pCi/g)				Strontium-90 [a] (pCi/g)		Cesium-137 (pCi/g)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
May–June	15	<0.74	<0.7–1.3	<22	<22	<2.7	<2.7	<2.9	<1.0–16
July–September	15	<0.85	<0.7–1.2	<22	<22	<2.7	<2.7	<2.1	<1.3– 9.8
October–December	15	<0.81	<0.7–1.8	<22	<22–29	<2.7	<2.7	<5.7	<1.3–52.9

[a] Three samples analyzed for strontium-90.

tions in Mohawk River sediment samples are given in table 3.

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 4.

Table 4. Radioactivity in Glowegee Creek sediment KAPL, February–December 1967

1967	Location	Number of samples	Gross gamma radioactivity (pCi/g)	
			Average	Range (low/high)
February–March	Upstream	1	4.5	4.5
	Downstream	2	29.2	3.1–55.3
April–June	Upstream	3	4.9	2.7– 8.2
	Downstream	3	3.8	2.3– 6.5
July–September	Upstream	3	1.8	1.6– 2.1
	Downstream	3	3.0	2.3– 3.7
October–December	Upstream	2	1.3	<0.1– 2.5
	Downstream	3	3.1	2.4– 4.1

The high gross gamma radioactivity reading for the one first quarter sample is attributed to fallout which had accumulated on Glowegee Creek ice and was subsequently collected with the sediment sample. Since all other results from upstream and downstream sediment samples are not significantly different, they indicate that Kesselring site operation has not increased the radioactivity of the Glowegee Creek bottom sediment above normal background levels.

Mohawk River fish radioactivity

Specimens of Mohawk River fish are collected annually at the Vischer Ferry Dam at the discharge point of the powerhouse effluent. This location is approximately 9,000 feet downstream of the Knolls site sewage outfall. Samples of the total body are analyzed for gamma radioactivity (cesium–137 equivalent) and samples of the edible tissues are analyzed for strontium–90 content and alpha radioactivity (plutonium–239 equivalent). The specimens, which were all carp, with the exception of one large mouth bass, were collected October 26, 1967.

The results of the radioactivity analyses of Mohawk River fish were all less than the values considered valid at the 90-percent confidence level with a precision of 30-percent. The average results of the eight specimens were: alpha radioactivity, <0.70 pCi/g; strontium–90 content, <0.27 pCi/g; and cesium–137 content, <0.29 pCi/g. The variation in the detectable level of the analyses is the result of differences in the size of aliquots; i.e., 10 grams for alpha radioanalysis, 100 grams for strontium–90 analysis and the total specimen for cesium–137 analysis.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation at the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, "Radiation Protection Standards."

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1966	April 1967
July-December 1966	October 1967

2. Shippingport Atomic Power Station[3] January–December 1967

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River in a site consisting of over 400 acres. The site is about 25 miles northwest of Pittsburgh and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 2). The station is designed to produce electric energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel, to heat exchangers where steam is formed in a separate isolated system.

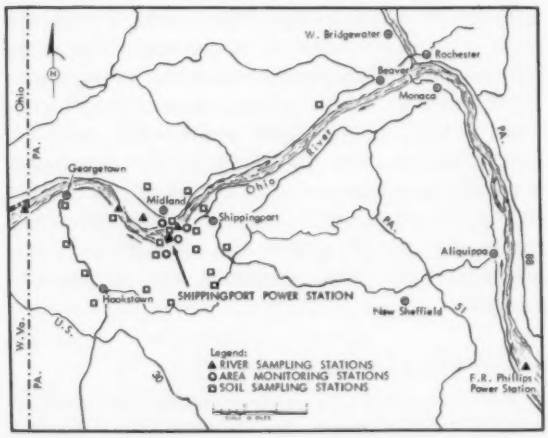

Figure 2. Shippingport power stations sampling locations

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released were below Shippingport discharge limits. These limits are based upon radiation standards set forth by AEC's division of Operational Safety in directives published in the AEC Manual [1], and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Ohio River water analysis

During 1967, with the exception of the second quarter, weekly composite samples were obtained from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive water effluent. During the second quarter of 1967, the two automatic samplers were rendered inoperative; thus, grab samples were collected each day during the radioactive waste discharges and combined at the end of the week into a 2-liter sample. Both suspended and dissolved materials in the composite samples were analyzed for gross alpha and beta radioactivity. Each composite is also analyzed for potassium–40 content. No significant difference was observed among the average alpha, beta, and potassium–40 radioactivity for the influent and effluent samples. The results of these analyses are presented in table 5.

Ohio River sediment analysis

Once during each calendar quarter, sediment samples of the Ohio River were collected upstream and downstream of the circulating water outfall. These samples were quantitated assuming all detected radioactivity to be cobalt–60, which is the major constituent of radioactive contamination at the station. The results of the sediment samples are presented in table 6. These data indicate that there was no increase of radioactivity in the river sediment as a result of the station's discharges.

Gaseous radioactive waste

Gaseous discharges to the atmosphere, identified as xenon–133, are controlled and released at concentrations less than the MPC of 3×10^5 pCi/m^3. During the entire year 1967, less than 1.9 millicuries of xenon–133 were released from the plant site at less than the specified concentration.

Film badge monitoring

Twelve film badges for detecting beta-gamma radioactivity were posted continuously at the

[3] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Calendar Year 1967."

Table 5. Gross radioactivity in the Ohio River Shippingport Atomic Power Station, January–December 1967,

Type of radioactive material	Average concentration (pCi/liter)							
	Influent samples				Effluent samples			
	First	Second [a]	Third	Fourth	First	Second [a]	Third	Fourth
Alpha:								
Total solids	0.79	1.16	0.63	1.53	0.69	1.26	0.38	0.77
Beta:								
Total solids	16.40	24.17	16.18	13.14	13.44	26.50	19.54	7.99
Potassium-40	3.69	3.3	4.9	3.72	3.77	3.6	4.9	3.75

[a] The average radioactivity for the second quarter of 1967 was computed from grab samples.

Table 6. Total radioactivity in the Ohio River sediment samples, Shippingport, January-December 1967

1967	Number of samples	Gross radioactivity (pCi/g)	
		Upstream	Downstream
January–March	2	8.60	9.35
April–June	2	7.13	6.53
July–September	2	6.04	5.77
October–December	2	6.23	6.40

Table 7. Radioactivity in fallout, Shippingport Atomic Power Station, January–December 1967

1967	Deposition rate (nCi/m²/month)	
	Alpha radioactivity	Beta radioactivity
January–March	0.12	[a]19.1
April–June	.23	3.69
July–September	.12	5.51
October–December	.08	[a]173.5
12-month average	0.15	5.04

[a] The high beta radioactivity reported in the first and fourth quarters of 1967 are attributed to fallout resulting from nuclear weapons testing.

site perimeter in an attempt to determine the external radiation exposure in the immediate area. In order to accomplish this, a control film badge location was established at a point 10 miles from the station boundary.

During the first and fourth quarters of this report period, the mrem equivalent taken from the normal quarterly film badges was equal to that of the control film. However, during the second and third quarters, differences of readings between the control film and the quarterly site film at several locations ranged up to 25 mrem equivalent. A further check of these differences indicated that they were not attributable to station activities, and that at no time during this report period was there any significant radiation exposure to the general public outside the facility.

Fallout

Precipitation and fallout are collected in a high-walled pot at one location on the site and analyzed monthly for gross alpha and beta radioactivity. A summary of the quarterly averages fallout results for 1967 is presented in table 7.

Conclusion

From the data presented above, it may be concluded that during 1967 the radioactive effluent releases from the Shippingport Station site did not cause any significant increase in background radiation levels. In this regard, the station procedures relative to controlling radioactive discharges to the environment are considered to be effective in protecting the health and safety of the general public.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1966	February 1967
July-December 1966	July 1967

Reported Nuclear Detonations, January 1969

The U.S. Atomic Energy Commission announced three underground nuclear tests for the month of January 1969.

Announcement was made by the U.S. Atomic Energy Commission of two nuclear tests, one of low yield (less than 20 kilotons TNT equivalent) and one of low-intermediate yield (20 to 200 kilotons TNT equivalent) were conducted underground at its Nevada Test Site on January 15, 1969.

A nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground by the Atomic Energy Commission at its Nevada Test Site on January 30, 1969.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PLUTONIUM–239 IN HUMAN TISSUES AND BONE. *Paul J. Magno and Peter E. Kauffman. Radiological Health Data and Reports, Vol. 10, February 1969*, pp. 47–50.

An average concentration of 7×10^{-11} μCi ^{239}Pu/g was found in human bone samples ranging in age from 2 to 24 years. This concentration results in an average dose equivalent rate of bone of about 3×10^{-4} rem/year. An average concentration of 7×10^{-10}μCi ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. These figures were compared to the Federal Radiation Council's Radiation Protection Guides and the dose limits recommended by the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection. From the data in this report, it was concluded that the concentrations of plutonium–239 in body tissue result in average dose equivalent rates well below the suggested radiation protection guides and dose limits.

KEYWORDS: plutonium–239, bone, liver, spleen, lung, United States, Radiation Protection Guides.

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February 1969

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